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ORIGINAL

Injuries and factors determining their occurrence in paratroopers of airborne forces

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background The purpose of this study was to determine the type and incidence of injuries among airborne forces paratroopers, and also to analyze the factors that determine the probability of suffering injuries while parachuting.

Material/Methods 165 soldiers in active service, from the 6th Airborne Brigade in Cracow, participated in the study. The survey was carried out via the author's questionnaire.

Results 32.72% of the examined soldiers were injured during the parachute jump. Crude injury incidence was calculated as 27.86/10,000 jumps. In terms of types of injuries, the frequency of their occurrence was as follows: sprains (34%), fractures (17%), muscle strains (13%), complete muscle ruptures (8%), partial muscle ruptures (8%), dislocations (6%), and others. The most common locations of the injuries were: the ankle joint (31%), the knee joint (24%) and the spine (18%). The most injuries (83%) happened during the landing phase of the parachute jump.

Conclusions The factors that increase the risk of injury during parachute jumps were as follows: higher body weight, older age, longer time of parachuting and serving in the Airborne Forces, greater number of parachute jumps. The most common reason for injury during parachuting was parachutist error.

Key words parachuting, parachute training, military, army, injuries

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INTRODUCTION

The specificity of military service, particularly of airborne forces, requires operational readiness of soldiers and thus ideal health, high physical efficiency, and high psychological resistance. Due to the exceptional character of such service, the physical preparation of airborne soldiers differs significantly from the physical education of civilians and soldiers of other military formations. The 6th Airborne Brigade in Cracow, named after General Stanisław F. Sosabowski, is considered to be one of elite units in the Polish army. This formation is a select, airmobile tactical unit trained to a high level. In military operations, qualified soldiers of this brigade may operate as parachutists, or as assault troops using helicopters. Service in the 6th Airborne Brigade requires parachuting, among other mandatory activities. Of course, training and actual parachuting may lead to injuries. Despite setting much store by the selection of candidates and individual training of soldiers, injuries linked with training and service are frequent in the military environment [1-4].

Parachuting is connected with a high risk of injuries, including fatal accidents. Parachutes are used recreationally by civilians who participate in this extreme sport, as well as by military and emergency service personnel (for example, fire brigades and rescue teams). According to data collected by the Polish Civil Aviation Department, the number of accidents in parachuting remains at a consistently high level compared to the number of accidents in other sports, such as hang-gliding, paragliding or motor-gliding (Table 1) [5].

Table. 1. Accidents in relation to aircraft type

Aircraft category	Number of accidents/ fatal accidents/ casualties					
	2006	2007	2008	2009	2010	2011
motor-glide, hang-glider, paraglide	16/5/6	12/4/6	11/2/2	12/4/4	17/6/7	22/10/10
parachutes	23/2/2	26/2/2	17/2/2	31/3/3	14/1/1	20/2/2

An injury sustained during a parachute jump is defined as one that occurs at any time from the moment of leaving an aircraft to the end of landing [6].

Factors influencing the risk of injury in military parachuting may relate to atmospheric conditions (wind speed and direction, temperature, and air humidity), drop zone characteristics and visibility, equipment (parachute or aircraft type, individual pack presence), training and task type, possession of additional equipment, and also the jumper's individual characteristics (weight, height, age, and sex) [4, 7].

Considering the phases of a parachute jump, the highest incidence of injuries is observed at the landing (touch-down) phase). In the event of a correct landing procedure, the jumper's musculoskeletal structure is slightly loaded, proportionally to a jump from a height of 1 meter but with a greater falling speed. Conditions increasing the risk of injury while touching-down are: incorrect position in relation to wind direction (the correct position is facing the wind), dangerous drop-zone, incorrect estimation of altitude and speed, recklessness, and erroneous assessment of atmospheric conditions [8, 9].

It is desirable in military operations to perform a jump from as low an altitude as possible. This can be achieved during jumps with self-opening parachute

systems (the parachute is opened by a rope attached with a snap hook to the wire line in the airplane). As a result of leaving the airplane incorrectly, the jumper is exposed to entanglement of limb or equipment. This may result in the jumper being hanged or sustaining injuries of the head, neck and upper limbs [8].

From analysis of accessible data it appears that the most frequent injuries in parachuting are: sprains and fractures of the ankle and knee joint, fractures of shin bones and the femur bone, and fractures of the upper limb. The most dangerous injuries include polytraumas, severe head injuries and spine injuries [10,11].

The aim of this study was to characterize the injuries sustained during parachuting, to evaluate their incidence, and to analyze the factors determining the occurrence of injuries.

MATERIAL AND METHODS

The study group consisted of 165 soldiers (including three women) from the 6th Airborne Brigade (the Gen. Stanisław F. Sosabowski Brigade) in Cracow. The study was conducted with the agreement of the Brigade high command. All examined people were informed about the goal of the study and gave their consent to participate. The inclusion criteria for each soldier were active military service and ongoing participation in parachute jumping. Jumps were performed from C-130 Hercules and CASA-295M aircraft, using AD-95, AD-2000, Feniks, Falcon, Parafoil and Sigma (tandem) parachutes. Exclusion criteria were injuries experienced during activities other than parachuting. Mean service duration time in the 6th Airborne Brigade was 67.4 months, and 111 people had previously served in a different airborne unit. Detailed characteristics of age, height, weight and service duration of the examined people are presented in Table 2.

Table 2. Study group characteristics

	Mean	Minimum	Maximum	SD
Age (Yrs)	28.99	21.0	44.0	4.41
Weight (kg)	80.41	52.0	105.0	8.69
Height (cm)	177.86	161.0	198.0	5.60
Service duration (months)	67.44	4.0	288.0	48.92

The study was conducted by means of a questionnaire especially designed for this purpose. The questionnaire consisted of 25 questions (of which 14 were single–choice, two were multiple choice, and nine were open), regarding sustained injuries and the circumstances of their occurrence.

Statistical analysis of the obtained data was carried out with a use of STATISTICA 10.0 (StatSoft, Inc.). Basic statistics and the Chi-Square Test were used as well as the t-student and U Mann-Whitney tests for comparisons between groups. The level of significance was $p < 0.05$.

RESULTS

The total number of jumps completed by 165 examined soldiers was 19,382, in which 54 of them sustained injuries. Crude injury incidence was calculated as 27.86/10,000 jumps. Analysis of the relationship between injury occurrence probability and age, body mass and height of examined soldiers is presented in Table 3. An established level of statistical significance was noted only in relation to age (p = 0.023). Participants who had sustained injuries were on average 1.66 years younger than people who had not been injured. Analysis suggested that height does not have a significant influence on the risk of injury (p = 0.878). In the case of body mass, however, the significance was almost at the established threshold (p = 0.09).

Table 3. The relationship between age, body mass and height andthe incidence of injuries during parachuting in the study group

Variable	Injury group mean	No injury group mean	t	p	n (injury)	n (no injury)
Age (yrs)	30.11	28.45	2.30	0.023	54	110
Weight (kg)	82.06	79.61	1.70	0.091	54	111
Height (cm)	177.96	177.82	0.15	0.878	54	111

Statistical analysis showed that experience and parachuting intensity are strongly linked with the probability of injury. Those who had sustained injuries had, on average, practiced parachuting 26.4 months longer, completed 254.7 more jumps altogether, and made 26.34 more jumps per season, in comparison to the group with no injuries (Tab. 4).

Table 4. Relationships between parachuting duration, total jumps, and number of jumps per season and the occurrence of injuries during parachuting in the study group

Variable	Injury group mean	No injury group mean	t	p	n (injury)	n (no injury)
Duration of parachuting [months]	84.15	57.75	3.14	0.002	54	111
Total jumps number	288.78	34.13	4.04	0.000	54	111
Jumps per season	32.98	6.59	4.04	0.001	54	111

The most frequent type of injury the in examined parachutists was sprain (34% of the group with injuries). The second most frequent was fracture (17%), followed by muscle strain (13%), partial muscle ruptures (8%), complete muscle ruptures (8%), dislocations (6%), and others, such as meniscus tear, concussion or breakage (15%) (see Fig. 1).

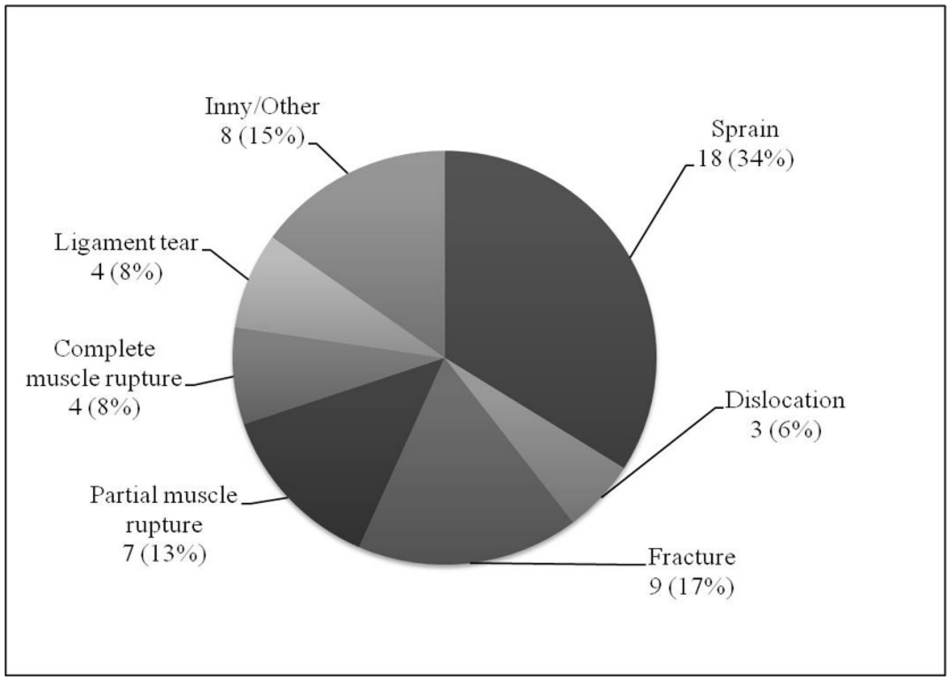

Fig. 1. Types of injuries sustained by the examined soldiers

Injuries were most frequently sustained in an ankle (31%), a knee (24%), and the spine (18%) The less frequent locations were an elbow (4%), a wrist (2%), a shoulder (2%), a hip (2%) and others, such as the head, a sacroiliac joint, a tibia and the quadriceps femoris muscle (17% - see Fig. 2).

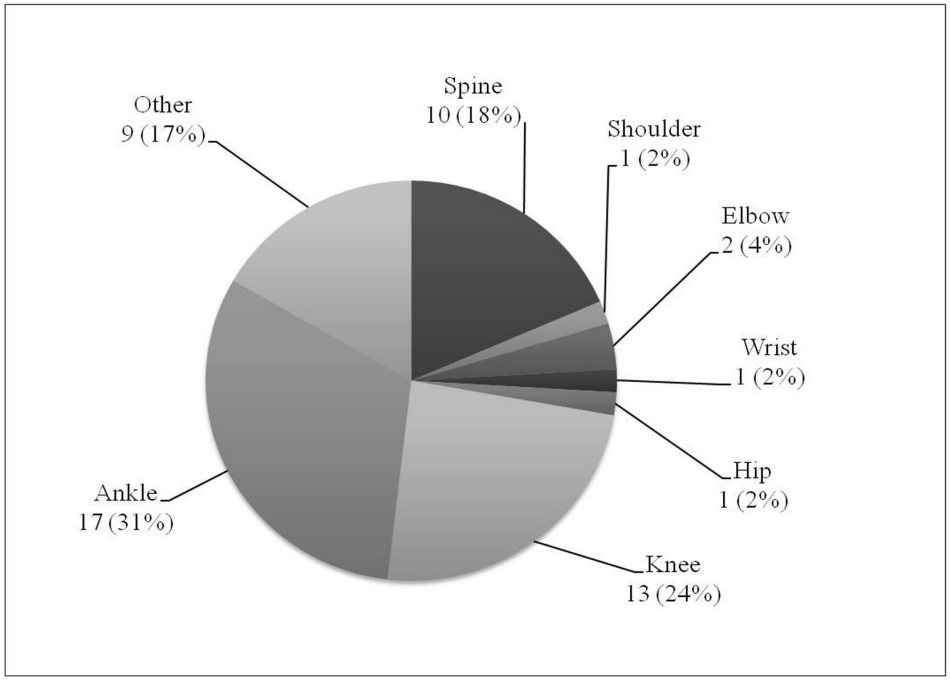

Fig. 2. Location of injuries in the examined soldiers

In light of our analysis, the greatest probability of sustaining an injury occurred during the landing phase, when more than 83% of injuries among the examined group occurred. Second was leaving the aircraft (15% of cases).

One injury occurred during the parachute opening phase. No injuries were noted during descent with an open parachute (Fig. 3).

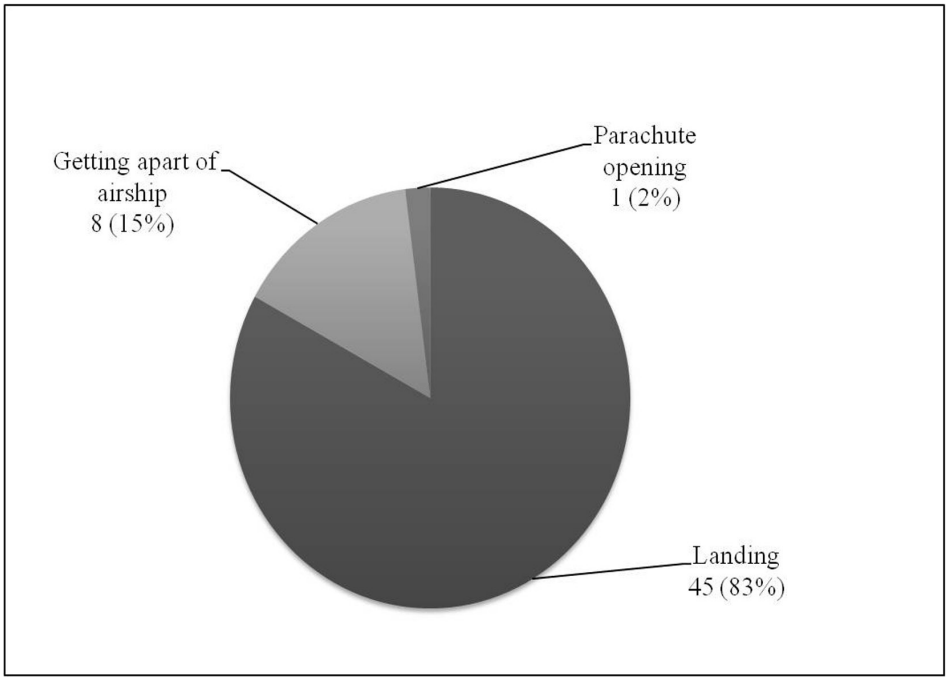

Fig. 3. Injury occurrence in relationship to the jump phase

Our analysis also revealed that injury was most likely to occur during a daylight jump without an individual pack (72%), followed by a daylight jump with an individual pack (24%). The least injuries (4%) were noted during night jumps (Fig. 4).

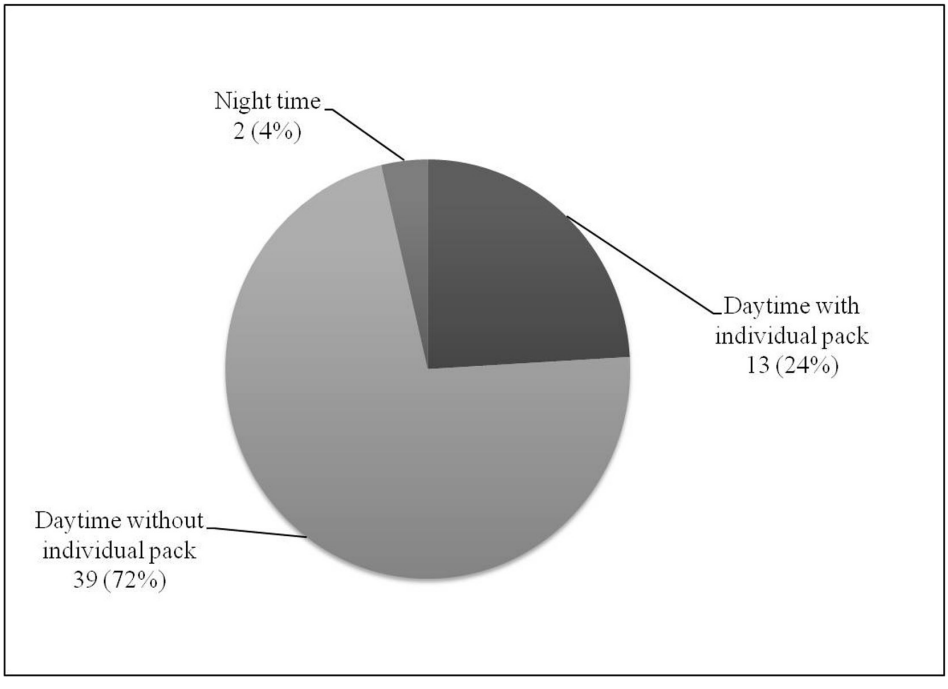

Fig. 4. Distribution of injuries in relationship to the jump type

The last analysis regarding causes of injuries showed that the most frequent causes were parachutist error (31%) and lack of experience (11%). Less frequent causes were recklessness (7%), defective equipment (4%), atmospheric conditions (4%) and others (43%) (Fig. 5).

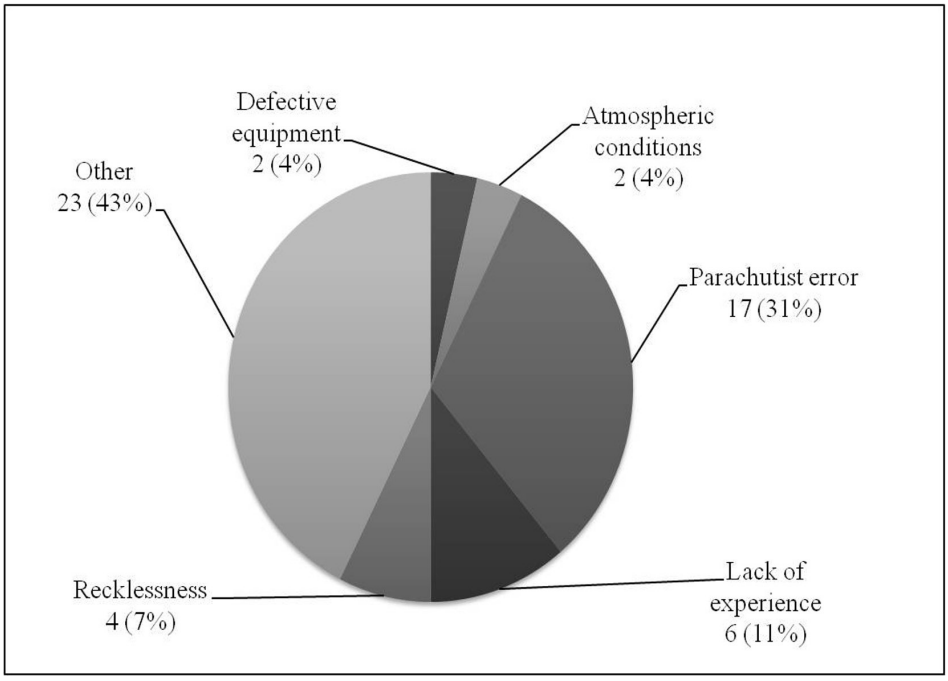

Fig. 5. Causes of injuries during parachuting

DISCUSSION

Parachuting, especially in the airborne forces, is characterized by quite a high rate of injuries. In our study, 54 out of 165 soldiers (32.72%) had sustained injuries, which is a relatively high rate. Studies carried out by other reasearchers confirm the high injury rate in parachute jumping. Hay analyzed the incidence of injuries among soldiers of the 3rd Australian Airborne Battle Group. The study group consisted of 378 soldiers, of which 21 (5.6%) had sustained injuries [12]. Another study was carried out in Brazil by Neves et al., during which analyzed data included accident reports, collected by the authors from January 2005 to August 2006. The incidence rate in this time period was 1.2%. As the authors fairly concluded, international comparisons in this field are still rare in the accessible literature [9].

Our analysis showed that the relationship between the jumper's body mass and the probability of injury during parachuting did not reach the required level of significance. Despite that, this relationship is placed near the mark of significance ($p = 0.09$) and thus could be potentially recognized as relatively significant. The probability of injury was higher in jumpers with higher body mass. Studies by other authors confirm the influence of body mass on injury probability. Research conducted by Hughes and Weinrauch, on a group of soldiers from the 4th Royal Australian Commando Battalion, confirmed that greater body mass increases the risk of injury, particularly in jumps in land drop-zones [13]. Knapik et al., in a study on paratroopers from the United

States Army Airborne School, concluded that greater body mass is linked to greater force during the touch-down phase, thus increasing the risk of injury in heavier jumpers [14]. Our study also discovered that a paratrooper's height did not have an influence on the probability of injury during a jump. Knapik et al. confirm this in their review regarding risk factors for injuries during military parachuting [4].

The collected data indicate the significant influence of age, experience and parachuting intensity on the risk of injury during jumps. Soldiers who had sustained injuries were older, had practiced parachuting for longer, made more jumps per season and altogether. However, Knapik et al. indicate that younger soldiers have an increased risk of injury. The authors explain this by the fact that younger soldiers perform more physically demanding tasks in comparison to older colleagues, who usually take higher appointments. Nevertheless, all soldiers, regardless of age and rank, perform the same tasks during basic training, and in such conditions older soldiers are more susceptible to injury [4].

Regarding the location of injuries during parachuting, we concluded that the ankle joint is the most frequent location (31%), followed by the knee (24%), the spine (18%), the elbow (4%), the wrist (2 %), the shoulder (2%), the hip (2%) and others such as the head, the sacroiliac joint, the shin bone, and the quadriceps femoris muscle (17%). This distribution of injuries is in accordance with distributions noted by other researchers [8, 9, 15]. Ball et al., in their study on a group of 110 military paratroopers, presented the following injury distribution: lower limbs (65%), the head (22%), the spine (22%) and upper limbs (19%). It is worth mentioning that, in this study, some soldiers had sustained several injuries at the same time [8].

In light of our analysis, the highest probability of injury was in the landing phase – more than 83% of injuries among paratroopers in the study group occurred in that phase – and leaving the aircraft was second (15% of cases of injury). The majority of other researchers confirm that most injuries during parachuting occur during the landing phase (86%, according to Ball et al. [8]). Knapik et al. defined injuries among 67% of examined soldiers as occurring during the landing phase (75%), and arising from static line problems (11%), tree landings (4%), entanglements (4%) and aircraft exits (3%) [7].

CONCLUSIONS

1. Greater body mass and higher age of paratroopers in the examined group increased the probability of trauma occurrence during parachuting. Height, however, did not influence trauma incidence.

2. The duration of parachuting and the length of service in the airborne forces is linked with a greater risk of injury.

3. A greater number of parachute jumps performed by an individual increases the probability of trauma occurrence.

4. The most frequent type of trauma among the examined paratroopers was ankle joint sprain, and the phase of parachuting during which traumas occurred most often was the landing phase.

5. The conducted study confirms the paratrooper error as the most frequent cause of trauma occurrence during parachuting.

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